Natural Sciences and Engineering Research Council of Canada

Conseil de recherches en sciences naturelles et en génie du Canada

12 YEARS TO 2000:

DRAFT DISCUSSION PAPER

NATURAL SCIENCES AND ENGINEERING RESEARCH COUNCIL OF CANADA

FEBRUARY 1988

Canada

88-05270/

Disponible en français sur demande

The science and engineering PhDs of the year 2000 are now in high school. Their numbers, as they enter the university age group (18-24), will decline steadily to the mid 1990s. Demand for their talent must certainly increase if the Canada of the 21st century is to be a competitive, developed nation. The following pages describe the role of the Natural Sciences and Engineering Research Council in meeting these demands and in facing the other challenges of research and knowledge transfer as the 21st century approaches.

Executive Summary

At the eve of the last decade of the 20th century, the Natural Sciences and Engineering Research Council (NSERC), the federal agency responsible for the support of university research in the natural sciences and engineering, has prepared a strategic plan designed to assist universities to attract the best minds to research careers, to make significant contributions to the advancement of knowledge, and to apply knowledge to improve the wealth and welfare of Canadians.

No one would any longer question the importance of technological advances for economic growth. Canada, with a cumulative $7 billion high technology trade deficit, is vulnerable in the emerging new economy and is not in the best position to improve industrial competitiveness. While some progress has been made in terms of industrial R&D investment in Canada over the past 10 to 15 years, the country still compares unfavourably with other industrialized countries in terms of overall investment in R&D.

The demographic situation also warrants action. The need for highly qualified personnel will likely increase if Canada wishes to improve its investment in R&D and its overall economic situation; yet demographic trends indicate a steady decline in the 18-24 age group to the mid 1990s. Vigorous measures to attract young Canadians to careers in science and engineering are called for.

While there is reason for concern with Canada's R&D performance, there is also reason for optimism: increasingly, different research partners collaborate in joint ventures; the research environment is more receptive to interdisciplinary projects; several provinces have launched programs designed at promoting and assisting research and development; and finally, the federal government has undertaken a number of initiatives likely to stimulate investment in research and development.

In this context, NSERC, the only federal agency directly responsible for providing support to university research and for providing assistance in the training of highly qualified scientists and engineers, is proposing a strategy that will be a key factor in maximizing the universities' contribution to Canada's readiness for the 21st century.

NSERC has three primary responsibilities: Its first responsibility is to secure a healthy research base in universities and, as a corollary, to secure a sound balance between the broad research base and more targeted programs of research. NSERC's second responsibility is to secure an adequate supply of highly qualified personnel who have been well educated in basic science as well as trained with state-of-the-art facilities. A third responsibility is to facilitate collaboration between R&D performing sectors in Canada. To discharge these responsibilities, NSERC has devised a long-term strategy that rests on both consolidation and change.

First, consolidation: Council believes that the design of its existing range of programs answers adequately the requirements of the research community, but that the funding level is too low to answer the pressing needs: augment the number of highly trained scientists and engineers to meet demands in university and industry; stimulate research in areas of national and critical importance, and collaboration between university and industrial research partners; and, most important and essential, strengthen the foundation of university research.

Second, change and new direction: Council is of the opinion that it is timely to exploit more systematically the concentration of research effort, especially in areas of great opportunity. To do so, it proposes a program of support for centres and networks that will, in conjunction with NSERC's existing programs, assist the research community in addressing the major challenges it faces. The key features of the program would be: flexibility, leadership, and stringency of the selection and review process. Centres and networks would vary in scale and intensity: NSERC would not predetermine the numbers of centres and networks to be supported or the areas of research. The selection process would be based on peer review.

1. Introduction

Seldom have research, science and technology been so high on the agenda of industrialized nations. All recognize that science and technology will be the engines of future economic growth. All recognize that science and technology are an integral part of the cultural fabric of contemporary society. The degree of excellence in university research, and therefore the availability of qualified researchers, will be the cornerstone of Canada's scientific and technological competence and economic competitiveness.

In 1985, the Natural Sciences and Engineering Research Council, the federal agency responsible for the support of research in the natural sciences and engineering, prepared a five-year plan focussing on the development of intellectual capital to meet the challenges of the last decade of the 20th century. Presented at a time when government priorities were governed by objectives of fiscal restraint, the five-year plan received a somewhat modest, albeit challenging, response - the matching funds policy. Intended to increase relationships between universities and the private sector, to encourage private sector contributions to university research, and to facilitate the transfer of knowledge from universities to the private sector, the policy is already bearing fruit. But the matching funds policy will not be sufficient to help universities meet the challenges of the knowledge-intensive economy of the 21st century.

To this end, as the primary source of funding of research in science and engineering at Canadian universities, NSERC is proposing a strategy that will assist universities to attract the best minds to research careers, to make significant contributions to the advancement of knowledge, and to apply knowledge to improve the wealth and welfare of Canadians.

2. A Changing Environment

2.1 The New Economy

Advances in science and technology provide the basis of productivity gains, establish the foundation for industrial competitiveness, enhance a nation's trading position, and, more generally, underpin a nation's economic vitality. Technological progress also carries a promise of an improved and sustained quality of life.

Both basic and applied research play central roles in the achievement of technological progress. The fortunes of research, industry, and the economy have become inseparable. The effects of this coupling in transforming the nature of modern industrial economies are manifest. There are far-reaching effects on the productivity and mix of industries; on the

products, processes and services that industries are capable of offering; on what is traded and with whom; and on the ways in which universities, industry and government collaborate in pre-competitive research. Research-driven technologies underlie every aspect of the transformation.

For Canada, the role of technological advances in economic growth is important for traditional as well as non-traditional economic sectors. Natural resource industries continue to play an important role in the Canadian economy, but challenges from increasing market competition are affecting the ability to reply effectively. To maintain their markets many resource industries are turning to new technologies to increase productivity at every level of the industrial process. Some industries have yet to adopt or adapt new technologies, but they must if they wish to remain competitive.

The relative importance of the natural resource industries has declined as the manufacturing and service industries have developed and diversified. In this shift, the mining, forestry and agriculture industries, which accounted for 32% of Canada's Gross Domestic Product (GDP) in 1945, now account for only 9.8%. The more technologically-intensive secondary and tertiary industries such as communications, electricity production, and manufacturing now account for 27.9% of GDP [1]. The mix is not the same in all regions of Canada. Some still rely preponderantly on the resource-based industries and feel particular pressures to diversify the economy.

The economic performance of the industries based on new technologies is outstanding, and although statistics are only partial, they show results far superior to those for the economy as a whole.

It is widely recognized that if Canada intends to participate fully in the international economy of the 21st century, it must develop and maintain the ability to produce a broad range of research-driven technologies. The country cannot afford to continue to buy technologies off the shelves of other countries. Not only does this leave Canada with a cumulative $7 billion high technology trade deficit, but it also means that Canada buys technologies that are not necessarily suitable for the country's needs [2].

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(1) Based on Estimates conducted by the Industry, Trade and Prices Branch of Statistics Canada in October 1987.

(2) Statistics Canada, International Trade in High Technology Products, July 1987.

2.2 The Research Environment

It has often been alleged that Canada's relatively poor R&D performance is due to the weakness of industrial R&D (and the dominance of government R&D), and there has long been a consensus concerning the factors accounting for the weakness, i.e., the resource-based economy and the branch-plant industrial pattern. However, over the last 10 to 15 years, there has been a noticeable change. Business and industrial enterprises now account for more than 50 per cent of Canada's gross expenditures on R&D (GERD), up by 18 % since 1971. Over the same period, the federal government share declined from 29 % to 20 %, the provincial government share remained almost constant and the higher education sector share dropped by 9%.

While these figures may lead to the belief that industrial R&D in Canada is considerably healthier than it was twenty years ago, there is still reason for concern. Only some 1,800 firms do industrial R&D: almost 40% of what is done is performed by 10 firms, 74% by 100 firms, and all the other firms perform the remaining 26%. Moreover, Canada is one of the few countries with a declining percentage of the labour force employed in R&D, a characteristic shared with only two other OECD countries, Spain and Greece.

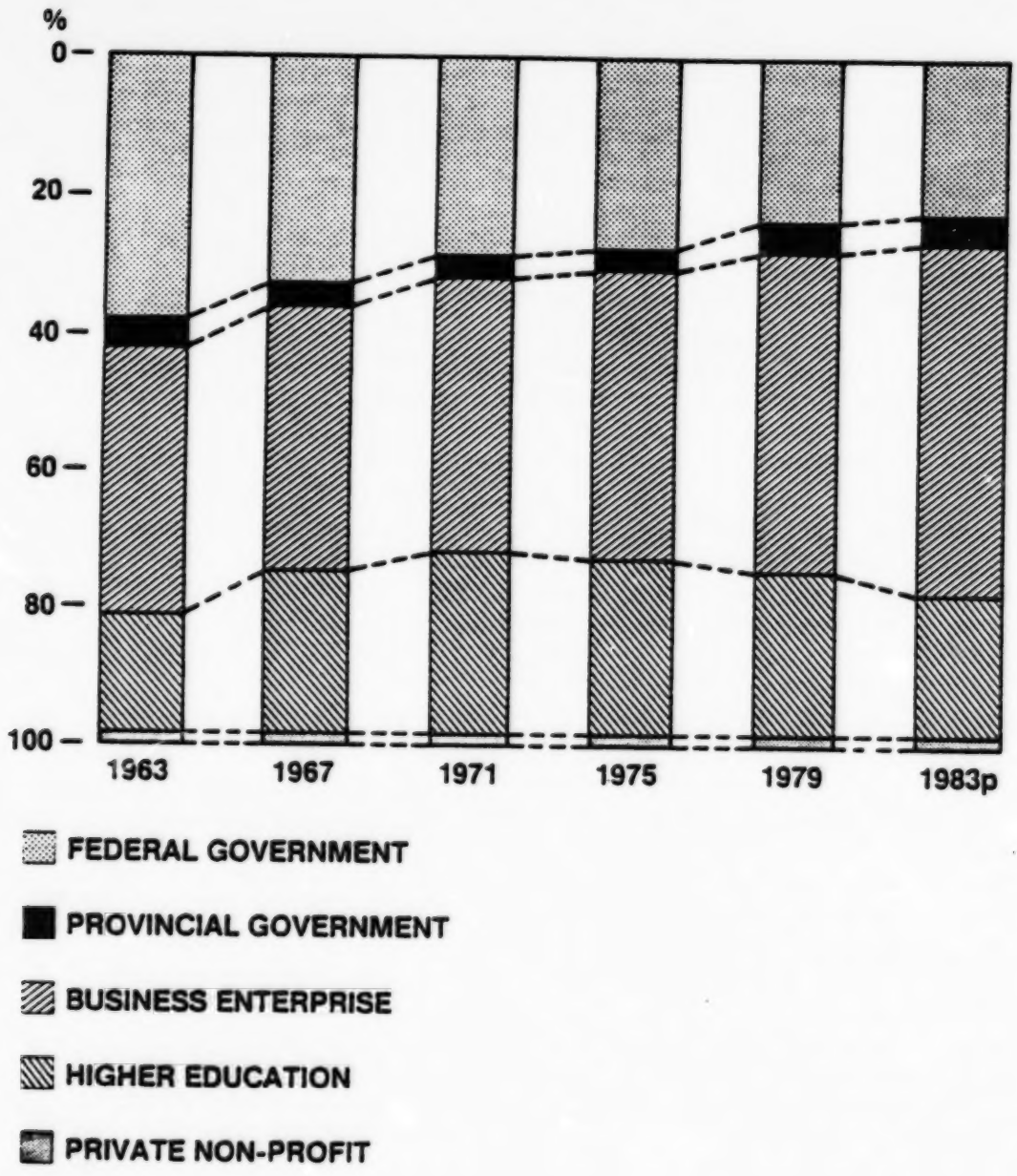
There is no doubt that this situation must be redressed, and rapidly, if Canada wishes to make a significant contribution to the advancement of knowledge and technological development and intends to remain a technically and economically advanced nation. To join the group of industrialized, and economically competitive, countries, Canada must aspire to increasing substantially its industrial R&D. Raising the GERD/GDP ratio from the current 1.31% to a more healthy 1.70% would place Canada in the same category as the U.K., still significantly behind the U.S. (1.93%), Japan (2.55%) and the Federal Republic of Germany (2.44%) (1984 Data - MOSST).

Assuming that Canada will improve its comparative situation, it is to be expected that Canadian industries will soon be in the marketplace for many more highly qualified personnel. It is a marketplace that for a variety of demographic reasons will be a sellers' market. On top of this increased demand from industry, one must not forget that the large cohorts of researchers hired by government and universities in the 1950s and 1960s will be due for replacement by the mid and late 1990s. In these circumstances, it is important to have a critical look at supply.

Demographic trends for Canada indicate a steady decline in the 18-24 age group to the mid 1990s (Graph II). To increase the overall level of spending on research and development to reach even a somewhat modest 1.7% of the GDP which appears to be, in the short term, a reasonable target, the Canadian university system must significantly increase the supply of HQP.

GRAPH I

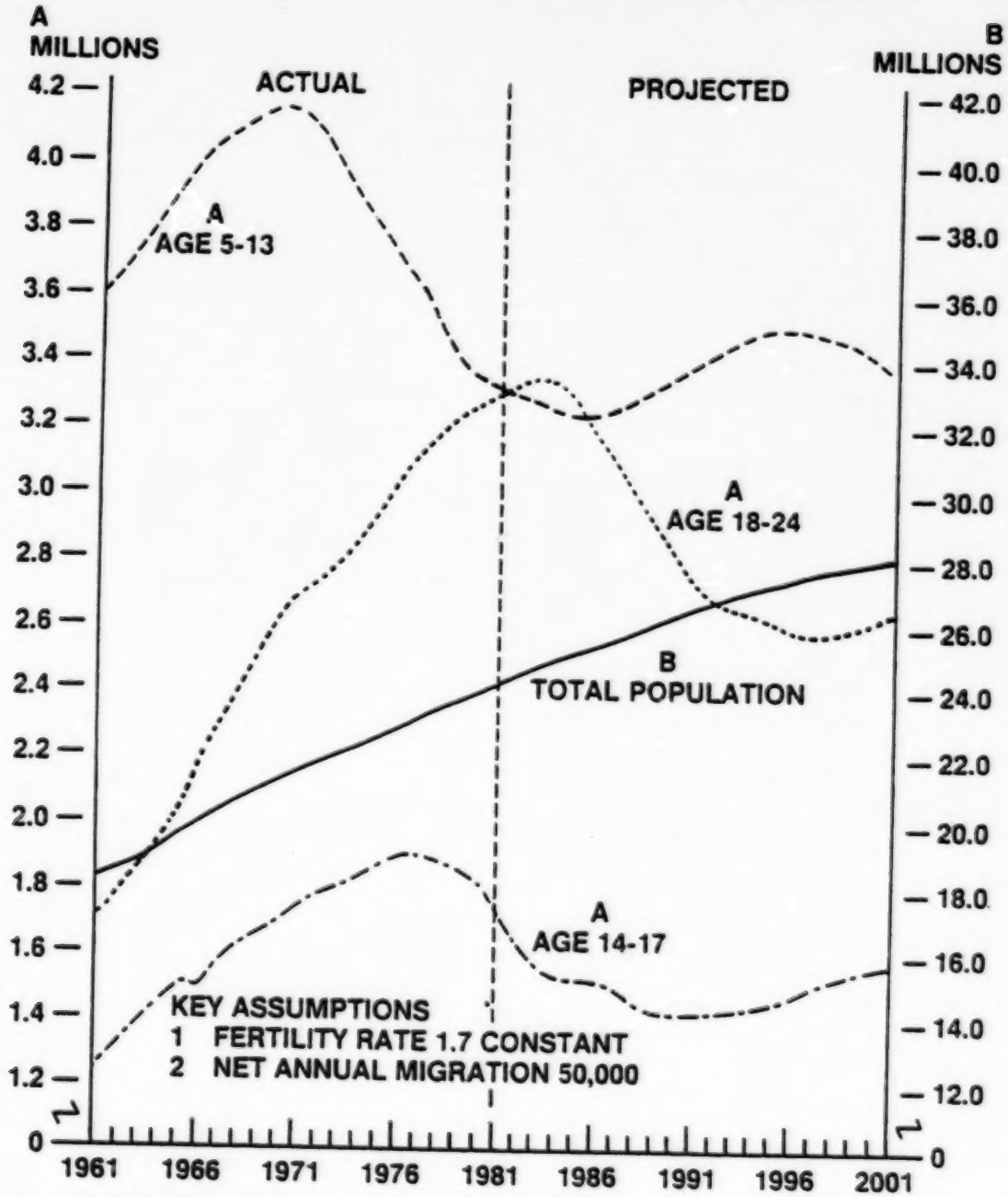
Changes in the Relative Positions of R&D Performing Sectors, 1963 to 1983



Industrial Research and Development Statistics 1982, Statistics Canada

GRAPH II

Selected Age Group Population Trends, 1961-2001



Source: Statistics Canada, Demography Division

Paradoxically, while the importance of science and technology in the development of the national economy is increasingly recognized, there has been little increase in the numbers of scientists and engineers receiving postgraduate degrees from Canadian universities over the past decade. In fact, if account is taken of the significant numbers of these degrees that have been received by students from other countries (and who are not eligible to obtain employment in Canada), the actual numbers of Canadians receiving master's or doctoral degrees in science and engineering are surprisingly small. In engineering and applied science, for example, the number of PhDs awarded to Canadians has been in the range from 100 to 150 per year.

The relatively modest numbers of Canadians receiving higher degrees has not been a problem in some disciplines. Indeed some surpluses have occurred, mainly because of demographic factors and because of the unusually low expectations for research and development in this country. Nevertheless, shortages have occurred and will continue to occur in fields such as biotechnology, computer sciences and some branches of engineering. Such shortages will be strongly felt if a strategy of increasing national expenditures on R&D is to be implemented successfully.

The reasons why relatively few Canadians have chosen to pursue graduate studies in science and engineering are many, and they differ in significance from one discipline to another. But the most important include unfavourable job prospects after graduate studies, low levels of scholarship support, attractive alternatives such as employment in industry without the requirements for graduate studies, inadequate research facilities in Canadian universities, and a culture that has not placed a high value on research and scholarship in general.

Aside from these chronic problems, the Canadian university research environment is moderately healthy by comparison with that of other industrialized countries. There is strength in science and engineering. A majority of university professors receive grants that enable the pursuit of the research that is essential to the quality and vitality of their undergraduate teaching. Grants from NSERC are a major factor in creating the milieu that is essential for graduate training, in which how to do research is learned by doing research alongside others who are doing research. Canadian university research is widely published in what are recognized as leading journals, and although Canada produces less than 5% of the world's scientific research, what is produced is of high average quality.

The universities thus represent a strong base on which to build the Canadian thrust to higher levels of R&D activity. Given the necessary resources, they can produce the required highly qualified personnel and, at the same time, join industry and government in a wide range of collaborative activities.

The research of the future, especially that on a large scale, is likely to require close collaboration among disciplines and among sectors. There has been an increasing emphasis on team approaches and on drawing on the strengths of various disciplines to answer questions and to solve problems. Equally important is the necessity for combining disciplines in addressing problems that inherently involve the social sciences (resource management and research and technology management are good examples). There are also

significant opportunities in the combination of the medical sciences with the natural sciences and engineering. Research funding of the future must have well-oiled mechanisms for the support of interdisciplinary research.

The gap between university researchers and their industry counterparts has never been as large as it has been said to be, but to the extent that it existed, it is rapidly being closed. In some areas, the time from discovery to commercial application has shortened dramatically. More than ever before, university researchers ha e a greater prospect of seeing their research used in the service of society.

Industry, acknowledging the same change in tempo, has moved the sights of its targeted research further toward basic science in order to get ahead of its competitors. Linkages between university and industry have multiplied. Many Canadian universities now have offices of technology transfer, operating as focal points for collaboration through such mechanisms as contract research, licensing agreements, and consultation services to small enterprises. The number of university spin-off firms and campus-based science parks has increased dramatically.

The private sector has been equally active. The establishment of the Corporate-Higher Education Forum alone demonstrates the interest of industry in developing new mechanisms of cooperation. The Canadian Manufacturers Association has underlined the importance of mobilizing the combined talents of university and industry. Many new associations are being formed to facilitate collaborative support of research for small industrial sectors.

Governments are also making efforts to increase linkages between universities and the private sector. The matching funds policy of the federal government was designed to stimulate collaboration and accelerate the transfer of knowledge and technology.

Quebec's "Virage technologique" strategy, Ontario's Centres of Excellence program, Alberta's Heritage Fund and British Columbia's Fund for Excellence in Education have been crafted to encourage joint activities and exchanges among partners in research.

Collaboration of universities with government laboratories has a long history in Canada. Many campuses host a government laboratory or two; there can be little doubt that the proximity of government and university researchers has worked to the advantage of both. Mutual access to facilities, the enhanced opportunities for students, and the increased awareness of each other's research programs, are all valuable aspects of government lab-university interaction.

In the provision of some major national facilities, such as ships, space craft and cyclotrons, universities are heavily dependent on the federal government for both initial and operating costs, and administrative continuity. The big science of the future will probably be no exception.

The research environment of the future will be the result of profound changes in the corporate culture (starting, for instance, by recognizing the crucial importance of R&D for industrial

strength and consequently changing hiring practices to include more scientists, engineers and technicians), in the traditional university structures and culture (questioning and removing barriers, reaching out) and in government departments responsible for developing science and technology policies and programs in support of research.

2.3 The Political Environment

Canadian governments, both federal and provincial, are increasingly recognizing the importance of R&D for economic development; as a consequence, science and technology are gaining an increasing visibility on the political agenda. Several recent federal structural initiatives seek to create a global framework for policy and decision making, and to stimulate investment in R&D in all sectors.

A Parliamentary forum was established to debate questions of science and technology; there now exists, for the first time, a Standing Committee on Research, Science and Technology.

Second, the federal government reviewed its advisory structure for science and technology and established a National Advisory Board for Science and Technology, chaired by the Prime Minister.

In March 1987, the federal, provincial and territorial ministers responsible for science and technology agreed on a National Science and Technology policy, and created a Council of Science and Technology Ministers to monitor the implementation of the policy.

Also in March, 1987, the federal government launched a strategy for science and technology, InnovAction. The objective of InnovAction is to focus federal science and technology activities in five specific areas: industrial innovation and technology diffusion, strategic technologies, management of federal resources, human resources in science and technology, and promotion of a science-oriented culture.

The Prime Minister recently announced that the Ministry of State for Science and Technology would be merged with the former Department of Regional Industrial Expansion to form a new Department of Industry, Science and Technology. This new department structure indicates the relative priority of science and technology, and their perceived ties with industrial development and economic growth.

Finally, at a National Conference on Technology and Innovation in Toronto in January 1988, the Prime Minister announced an additional federal investment of $1.3 billion in research over the next five years.

The thrust of Canada's science and technology policy is shaping up; its content is in the process of being defined.

The growing importance of science and technology on the political agenda is equally evident on provincial agendas, but there are significant differences in the amount of R&D funded

by the various provinces. Many provinces have recently launched major endeavours intended to stimulate research effort, especially in subject areas that are perceived to be good investments for provincial economic growth. The development of complementarity in federal and provincial programs will be an important feature of national research and development in the next decade.

At a time when several initiatives are materializing and providing a stimulating context to take up the challenges of the new economy and the changing research environment, NSERC decided to take a fresh look at its particular role and to ascertain the nature and value of its potential contributions.

It is clear that Canadian universities will play a major, crucial role in the enhancement of Canada's research effort. Only ***they*** can enrich the brain-power of the country by educating future scientists and engineers, by providing research training and exposure to activities taking place at the interface between the university and the surrounding community. It is in assisting universities to fulfill their three fundamental missions that NSERC will be able to contribute fully to Canada's research strategy of the 21st century.

While the national effort to augment R&D activities will involve many agencies of the federal government, only NSERC has the primary role of funding university research in the natural sciences and engineering and the primary responsibility of ensuring, at the federal level, the health of Canada's university research base.

The challenge of the 21st century is, in this regard, NSERC's as well as that of Canadian universities and industries. That is why the strategy calls for a considerable strengthening of NSERC's existing programs as well as a new approach to research funding. It is a strategy of intensification on the one hand and innovation on the other.

3. NSERC's Role and Objectives

Over the past 40 years a number of changes have been made in the policy and programs that NSERC now administers, changes that were designed to be responsive to the current national need. For many years, scholarship and grant programs were designed primarily to build a basic national scientific and engineering competence, helping to build the higher education institutions of the country by fostering the research enterprise. In the 1960s and 1970s, negotiated development grants were aimed at building capabilities in particular fields at particular institutions. In the early 1970s, industrial postdoctoral fellowships and university-industry grants were introduced. The strategic grants program began in the late 1970s and was aimed at subject areas that were deemed to be of national significance. University research fellowships were created in the 1980s for young researchers who might otherwise not have been employed in Canada.

The present ensemble of NSERC programs provides for the support of a continuous spectrum of research and development activities. There is a broad base of pure and applied research which generates ideas for both strategic research aimed at particular problems and

university/industry research for exploration of commercial potentials. Embedded throughout is the invaluable element of training of the next generation of researchers. It is this element that distinguishes NSERC from all of the other federal agencies that participate in science and technology activities.

NSERC has three primary responsibilities: Its first responsibility is to secure a healthy research base in universities and, as a corollary, to secure a sound balance between the broad research base and more targeted programs of research. It is to be emphasized that targeted research is taken to mean research that is aimed at a particular subject area or scientific problem. It may be basic or applied, or a mix of the two, and is aimed at making something happen that otherwise would not. It commonly involves more than one individual researcher and may involve collaboration with industry and/or government. Success in targeted research can only be achieved by first having a clear vision of the target and then putting together an appropriate team or structure to do the job.

NSERC's second responsibility is to secure an adequate supply of highly qualified personnel who have been well educated in basic science and well trained with state-of-the-art facilities. Apart from the consideration that the health of the research system is predicated upon the development of human capital, contemporary considerations make this responsibility crucial. There is an incipient shortage of research-trained scientists and engineers, and the world of knowledge is growing rapidly.

A third responsibility has been more recently recognized: to facilitate collaboration between R&D performing sectors in Canada, and thus to provide mechanisms that will improve the transfer of knowledge and technology.

To discharge these responsibilities, NSERC has devised a long-term strategy that would lay the foundation for an increased research effort that would better prepare Canadian society for the challenges of the 21st century.

The approach is twofold: first, to strengthen the whole chain of existing programs, thereby improving the base on which everything is built; and second, to foster excellence in emerging areas of scientific discovery and promise by the introduction of a highly flexible new program for the funding of national networks and centres. Such networks and centres would reinforce excellence in Canadian universities, pool research talents and establish bridges among different research partners.

4. A Strategy

4.1 The Research Base

The best efforts of universities will be required if Canada is to keep pace with contemporary science and technology. As their strongest link to the federal government, NSERC must ensure, through programs in support of the research base, that universities are able to play

their roles fully. Reviewing its mandate, the Council unequivocally reaffirmed its conviction that NSERC should primarily fund individuals and teams at universities and that the prime source of federal funding for research at universities should be NSERC. Operating grants, which are the major source of support for scientists and engineers in Canadian universities, are not only the cornerstone of NSERC's program structure, but they are also the foundation of the entire Canadian university research effort in science and engineering. What other agencies may do in support of science and technology at Canadian universities is built on the NSERC base.

The operating grants program supports quality wherever it is found, and recognizes the importance of providing higher levels of grant support to the best researchers in the country. (The top 10% of researchers currently receive 25% of the funds.) Just as important, it seeks to support the best of the new researchers and to give them every opportunity to succeed.

Deliberately, under the operating grants program, Council spreads its investment across a wide range of fields of study, across a range of performance and across the range of institutions in the country. This policy has many advantages in the sense that pockets of researchers are alive and well when a new unpredictable development (such as high temperature superconductivity) occurs; but it also has its drawbacks, especially in situations of tight funding. For instance, even though there is a wide spread in the range of funding to different individuals, it is well documented that the best researchers do not receive sufficient funding to perform at the level they could. Moreover, as the research community continues to grow, more new applicants enter the system than there are researchers leaving the system. There is not enough money to go around and, as a result, many researchers tailor their research to topics that can be pursued cheaply, rather than to problems that offer more intellectual excitement and promise.

For operating grants, the strategy proposes significant increases to the grants of the top 10% of researchers, and funding to help new academic staff start their research careers with adequate resources. The strategy does not include additional funding for the "established research force," although the strategy for human resources includes a provision to increase stipends of graduate students employed on operating grants.

Council also wishes to enhance its capacity to respond quickly to new ideas and new developments and to help the research community to seize challenging opportunities as they appear. As one of the means to achieve this goal, it proposes to increase its investment in the support of collaborative research initiatives.

While it is evident that the availability of up-to-date research equipment is essential for research and research training, NSERC-sponsored studies have confirmed that funding for the purchase, operation and maintenance of equipment is far from adequate, especially for young researchers who are just starting up. Because of financial restraints and because of the priority it has always attached to people, Council has not been able to devote sufficient resources to the equipment base. Yet, the capability of universities to work effectively with industrial and government partners depends heavily on the availability of suitable equipment.

Council's proposal would be to devote to equipment grants sufficient resources to fund at least one in three applications (success rate of approximately 35%). Capital investment entails costs for the maintenance and operation of equipment. Hence, Council would increase funding for infrastructure grants in support of equipment and facilities that are highly specialized, that cannot be supported easily by user fees, and that are commonly for regional and multidisciplinary centres.

These initiatives represent the minimum requirement to sustain the health of the research base in Canadian universities. Should NSERC not be in a position to provide this kind of support, it is doubtful that the universities will be able to retain and attract the researchers that Canada needs to attain national objectives in the fields of science and technology, or to provide students with the high quality training that cannot be divorced from leading-edge research.

4.2 Human Resources

With the strong prospect of an increasing demand coupled with a decline in both undergraduate and graduate enrolments in the 1990s, it will be crucially important for NSERC to provide new incentives to attract bright young minds to science and engineering. NSERC currently provides scholarships for between 20% and 25% of the graduate students in the science and engineering fields and is the pace setter for the level of support for better students.

The strategy upon which the plan for scholarships and fellowships programs is based consists of the following elements:

Stimulate an increase in the numbers of science and engineering students entering graduate programs, particularly at the doctoral level, by:

- increasing the number of undergraduate student research awards;
- increasing the number and value of postgraduate scholarships;
- increasing the value of stipends paid from research grants to graduate students; and
- introducing differential stipends for postgraduate scholarships at the doctoral level.

Encourage young researchers to enter careers in industry by restoring to former levels the number of industrial research fellowships.

Increase the number and value of postdoctoral fellowships.

4.3 An International Thrust

In view of the importance of science and technology as an element in international relations and competitiveness, and given the special role of NSERC in support of university research and research training, it is appropriate that Council play an active part as a facilitator of international scientific interactions involving university researchers and students. The Council's current involvement in such activities is through many different programs, including some specifically designed to foster international collaboration, as well as through efforts of Council members and staff. Council's actions in this domain have been, to date, limited in scope and only loosely coordinated. Council intends to adopt a strategy for its international activities which will be consistent with a set of objectives aimed at enhancing the opportunities for Canadian universities and researchers to benefit from expertise in other countries. The strategy would entail an increase in the funding available for international research collaboration as well as some re-structuring and improvement of existing programs.

4.4 Research in Areas of National Importance and the Transfer of Knowledge and Technology

The strategic grants program has focussed in the past on a relatively small number of broadly defined areas augmented by an "open" competition to cover everything else. This structure has been successful in the sense that the funds have been used effectively for their intended purpose and that research results have been produced and made available to the user sector.

Council will continue this program, but the number and breadth of areas may be modified in the near future, as a result of an on-going study. The study, managed by the Science Council of Canada on behalf of NSERC, involves broad consultations with the user sector. The intention is to select a number of topics for precompetitive university research. Topics will be oriented toward the generation of new and improved techniques, processes, materials and products, or improved understanding of the fundamental science underlying them, in the areas of enabling technologies such as information technology, biotechnology and advanced industrial materials. Other topics will also be focussed upon areas of national strategic resource, industrial or social interest. Unfortunately, the present funding situation makes it impossible for Council to support research in more than a few topics at a time. Thus, an additional investment in strategic research is required if universities are to accelerate their research effort in areas of national concern selected through a broad consensus.

The university-industry programs have taken off dramatically since the announcement, in February 1986, of a matching fund policy whereby government increases NSERC's budget by an amount equal to funding received by universities for research from the private sector. The response from both sides to the various program elements, especially industrial research chairs and cooperative R&D grants, already exceeds initial forecasts. NSERC now estimates

that demand will increase from $18 million last year (1986-87) to $21 million in 1987-88, $30 million in 1988-89, $40 million in 1989-90 and $50 million thereafter. These increases will be funded through the matching fund policy and thus will not draw from the Council base funding.

4.5 Centres and Networks

Over the past decade, there have been many reports advocating the establishment of national or provincial centres of excellence in science. The arguments for establishing research centres and networks include: concentration of resources, inter-disciplinarity, maximization of investment, concentration of expertise, multi-source funding and accelerated transfer of knowledge and technology.

Council is convinced that all these arguments strongly favour setting up a centres program at a national level, and that it is timely to do so. It is increasingly obvious that research centres now promise to become essential integrators of the different elements of the research spectrum. The strategy therefore proposes an ambitious program that will, in conjunction with NSERC's existing programs, assist the research community in addressing the major challenges it faces: intensifying Canada's research effort, developing further intersectoral collaboration, facilitating interdisciplinary research enterprises and adequately supplying the highly qualified personnel that the country will need.

4.5.1 The Design

The primary goal of the program will be to exploit opportunities in science and technology where the complexity of the research problems, or the resources needed to solve them, require the advantages of scale, duration and concentration of effort.

Key features would be: flexibility, leadership, and stringency of the selection and review process. There is no single recipe for excellence: depending on the areas of research, on the institutions involved, on provincial governments' interests, each centre or network will have its own characteristics.

This flexibility would apply to the very concept of centres. Centres would not necessarily refer to a single physical concentration of resources, but could refer as well to networks of science and engineering research concentration.

Therefore, centres and networks could display diverse organizational structures, ranging from a central activity involving multi-disciplinary research across faculties, to a linkage of many universities for a comprehensive research program. Centres could be developed around complementary themes in particular fields, regrouping researchers from many institutions; they could be organized around a common facility, set of experimental techniques, common data base or research instruments at a single institution; they could be

networks of researchers from several institutions who interact frequently by telecommunications or other means.

The flexibility of this concept would also apply to the areas of science and engineering that would be selected for support: no area would be pre-identified.

While the centres or networks would be university-based, the program would instigate the participation of industry, and provincial and federal laboratories. Therefore, the source and mix of funding would vary, in recognition of the fact that the cost and scale of the research will differ greatly from one centre or network to another, depending on the research challenges and opportunities. Some centres and networks could be large consortia involving several universities, industrial and governmental participants and involve several millions of dollars a year in funding. Others could be more modest in scale.

In addition, because centres and networks could range widely in scale and intensity, NSERC would not predetermine the number of centres or networks to be supported.

The networks and centres will rest on strong scientific leadership: the excellence and demonstrated creativity of a research team and its leader will be the strongest feature of a program designed to support world-class, leading-edge research in Canada. Such leadership is an essential prerequisite not only to ensure outstanding accomplishments, but also to provide guidance for graduate students and postdoctoral researchers and to attract the best researchers, industrial and government scientists and engineers and top-ranking visiting researchers from abroad.

The proposed criteria for the networks and centres program would therefore be:

- excellence, both in terms of the individual and group track record and the proposed research program;
- scientific leadership and creativity;
- focus of the research program;
- potential for training researchers;
- potential benefits to the Canadian economy and Canadian society;
- potential for multidisciplinary integration and synergism;
- interconnections between university groups, industrial research laboratories and provincial and federal laboratories;
- management structure;
- potential for international leadership.

The program would have a solid review mechanism for each network or centre after 3 years to ensure that performing centres would receive assurance of continued support, while provisions would be put in place to phase out the funding of centres or networks that did not live up to expectations and promise.

4.5.2 The Administration

NSERC will monitor closely the harmonization of the centres and networks program with provincial actions with regard to centres and will make sure that mechanisms for negotiations with the different parties are adequate. In this regard, it is important to note that, through its existing programs, NSERC already has contributed to the creation of centres and networks and has already substantial experience.

Since proposals for centres and networks may well involve, in some cases, researchers in the medical sciences or the social sciences and humanities, NSERC would seek to develop terms of collaboration with MRC and SSHRC to deal with proposals of potential mutual interest.

The selection process will be based on peer review. Proposals will compete against each other and the selection will be made on the basis of their merit with respect to the foregoing criteria. A panel of experts of international calibre will make recommendations to NSERC and, in order to ensure that the most outstanding people will serve on such a panel, its recommendations will be in the public domain.

4.6 Budget

The strategic plan would have the following impact on NSERC's program clusters:

A. The research base budget would increase by 50% over a five-year period; the emphasis in the distribution of the budget would be mainly in areas of equipment and support for infrastructure, as well as extra support to the top echelon of grant holders while making provisions for new entrants.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
201	255	280	295	302	310

B. The Scholarships and Fellowships budget would increase by 60%. This would permit increased stipends as well as an increase in the number of awards offered.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
55	75	80	90	90	90

C. Funding for research centres and networks would add, over the next five years, $280 million to NSERC's budget.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
0	20	40	60	80	80

D. The relative increase in the targeted research budget would be the most significant, being slightly above 100%, to take advantage of growing potential for university/industry interaction and to foster team building in strategic research areas.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
52	70	90	110	110	110

E. The increase in general research support is essentially premised on the increased incentives under the matching fund policy and modest increases in International Relations activities.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
17	25	35	43	43	43

F. The administrative budget necessary to carry out the new elements of the proposed strategy will remain at approximately 4% of the total budget.

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
13	18	21	24	24	25

Total

Forecast	Proposed Budget				
	(in millions of dollars)				
1987-88	88-89	89-90	90-91	91-92	92-93
338	463	546	622	649	658
Currently approved	354*	378*	404*	311.6+?	311.6+?**

The proposed increase would thus almost double the budget of NSERC over a five-year period. The scientific and engineering community of Canada is fully capable of using an increase of this size with efficiency and imagination. Indeed, if it is to serve the national interest as it should, an increase of this magnitude is essential.

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* includes matching funding amounts of 40.5, 64.0, 90.0 million dollars.

** approved ongoing base is 311.6 million dollars.

5. Conclusion

A number of recent events has highlighted the importance of university research and of the training of scientists and engineers: the National Forum on Postsecondary Education, the work of the university committee of the National Advisory Board on Science and Technology (NABST), the National Conference on Technology and Innovation, to mention just a few. The universities are called upon to enhance their contribution to Canada's economic competitiveness and social well-being and are ready to take up the challenge. They cannot, however, given their generally tight financial situation, take up this challenge without the vigorous assistance of government and the private sector. In this regard, NSERC has a major role to play and the Council is convinced that the strategy it proposes will be a key factor in maximizing the universities' contribution to Canada's readiness for the 21st century.

February 1988